

EXHIBIT 4

Work-Related Lung Disease Surveillance Report 2002

Division of Respiratory Disease Studies
National Institute for Occupational Safety and Health

U.S. Department of Health and Human Services
Public Health Service
Centers for Disease Control and Prevention

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Preface

This *Work-Related Lung Disease (WoRLD) Surveillance Report* is the sixth in a series of occupational respiratory disease surveillance reports (see page iv) produced by the National Institute for Occupational Safety and Health (NIOSH). It presents summary tables and figures of occupational respiratory disease surveillance data focusing on various occupationally-relevant respiratory diseases, including pneumoconioses, occupational asthma and other airways diseases, and several other respiratory conditions. For many of these diseases, selected data on related exposures are also presented.

The 2002 *WoRLD Surveillance Report* has three major sections: (1) a section that provides data highlights and data usage limitations; (2) a section comprised of 15 subsections, each concerning a major disease category and (where available) related occupational exposures, and one subsection concerning smoking status; (3) a section of appendices that provide descriptions of data sources, methods, and other supplementary information.

Similar to the 1999 *WoRLD Surveillance Report*, this report includes data on hypersensitivity pneumonitis, asthma, chronic obstructive pulmonary disease, respiratory conditions due to chemical fumes and vapors, and other work-related respiratory conditions, in addition to the pneumoconioses. This report updates pneumoconiosis mortality data published in the 1999 *WoRLD Surveillance Report* by the addition of currently available data for 1997 through 1999. Pneumoconiosis conditions highlighted include asbestosis, coal workers' pneumoconiosis, silicosis, byssinosis, and pneumoconioses coded as either "unspecified" or "other," and all pneumoconioses aggregated. The current report presents data on conditions not included in earlier reports (e.g., malignant mesothelioma, lung cancer, and other interstitial pulmonary disease), plus data on smoking status by industry and occupation.

For many of the conditions reported on, the 2002 *WoRLD Surveillance Report* presents national and state summary statistics such as counts, crude and age-adjusted mortality rates, and years of potential life lost to age 65 and to life expectancy. Proportionate mortality ratios by industry and occupation are based on the most recent decade of data from a subset of states (see state list, Appendix E) for which usual industry and occupation have been coded for decedents. Also presented are U.S. state- and county-level maps showing the geographic distribution of mortality and, for the pneumoconioses, tables and figures summarizing selected occupational exposure data for asbestos, coal mine dust, silica dust, cotton dust, etc. (see agent categories, Appendix F).

Data contained in the 2002 *WoRLD Surveillance Report* originate from various publications, reports, data files, and tabulations provided by the Association of Occupational and Environmental Clinics (AOEC), the Bureau of Labor Statistics (BLS), the Department of Labor (DOL), the Mine Safety and Health Administration (MSHA), the National Center for Health Statistics (NCHS), the Occupational Safety and Health Administration (OSHA), NIOSH, and the Social Security Administration (SSA). Details on the major data sources and on the methods used to compute specific statistics can be found in Appendices A and B, respectively.

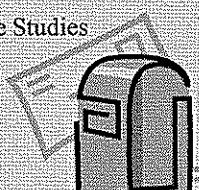
Interpreted with appropriate caution, the information contained in this report can help to establish priorities for research and prevention. It is also useful for tracking progress toward the elimination of important preventable occupational respiratory diseases, including those targeted in U.S. Public Health Service *Healthy People* objectives for the nation.

Comments and suggestions from users of earlier editions of the *WoRLD Surveillance Report* have influenced the content and format of this 2002 edition. To increase the utility of future editions, comments on the current report, descriptions of how the information is or could be used, and suggestions of other data for inclusion in future reports are invited.

See page ii of this report for information on how to order copies of previous *Work-Related Lung Disease Surveillance Reports*, described on the next page.

Send comments, suggestions, and other correspondence to:

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Summary of Previous WoRLD Surveillance Reports

WoRLD Surveillance Report (1991)

www.cdc.gov/niosh/91-113.html

The 1991 report is the first in the series of *WoRLD Surveillance Reports*. Data presented in the report, most of which relates to the 1968-1987 time period, originated from the National Institute for Occupational Safety and Health (NIOSH), the National Center for Health Statistics (NCHS), the Bureau of Labor Statistics (BLS), the Mine Safety and Health Administration (MSHA), the Occupational Safety and Health Administration (OSHA), the Department of Labor (DOL), the Health Care Financing Administration (HCFA), and the Social Security Administration (SSA). The 1991 report is organized into two major sections, one of figures and the other of tables. Within each section, data are presented in the following sub-headings: asbestos, coal workers' pneumoconiosis, silicosis, exposure to cotton dust, pneumonopathy due to inhalation of other dust (i.e., byssinosis), hypersensitivity pneumonitis, toxic agents, dust diseases of the lung, and compensation.

WoRLD Surveillance Report Supplement, 1992

www.cdc.gov/niosh/91-113s.html

The 1992 supplement presents updated data for many of the figures and tables presented in the 1991 report, including mortality data through 1988. In addition, the 1992 supplement includes data not previously presented: (1) sex, race, geographic distribution, usual industry, and usual occupation, supplementing mortality data presented in the 1991 report; (2) number of discharges with silicosis, asbestos, or coal workers' pneumoconiosis from the National Hospital Discharge Survey; and (3) reports of occupational asthma and silicosis from the Sentinel Event Notification Systems for Occupational Risks (SENSOR) Program.

WoRLD Surveillance Report, 1994

www.cdc.gov/niosh/94-120.html

Data presented in the 1994 report originate generally from programs and activities described in the 1991 and 1992 reports. The 1994 report is divided into 11 major sections, most containing both figures and data tables. Ten sections summarize mortality and morbidity data and other information, such as occupational exposures, for types of pneumoconiosis, malignant neoplasms of the pleura, hypersensitivity pneumonitis, occupational asthma, and other lung conditions. The final section provides data from the Association of Occupational and Environmental Clinics (AOEC) Disease Surveillance Database. The 1994 report contains major additions, including previously unreported data, such as those from the National Health Interview Survey (NHIS) and the AOEC, and additional statistical measures, such as proportionate mortality ratios, both crude and age-adjusted rates at national and state levels, and years of potential life lost to age 65 and to life expectancy.

WoRLD Surveillance Report, 1996

www.cdc.gov/niosh/w7wrld96.html

The 1996 report focuses entirely on pneumoconiosis mortality and related exposures, providing updated mortality data from 1968 through 1992. It has three sections: (1) a section that describes data highlights and data limitations; (2) a section that updates and expands national data provided in the 1994 report; and (3) a section that provides detailed profiles of relevant data for each state in the U.S. Surveillance data include counts, crude and age-adjusted rates, years of potential life lost, and proportionate mortality ratios by industry and occupation. The 1996 report presents detailed tables of pneumoconiosis mortality data for each state and for the District of Columbia, as well as for counties within each state. It also presents county-level maps showing the geographic distribution of mortality for each pneumoconiosis and showing results of federal occupational exposure inspection sampling for agents that cause pneumoconiosis.

WoRLD Surveillance Report, 1999

www.cdc.gov/niosh/W99front.html

The 1999 report is similar in content and organization to the 1994 *WoRLD Surveillance Report*. It is structured into three sections with 13 sub-sections which summarize mortality and morbidity data and other information, such as occupational exposures, for each type of pneumoconiosis and all pneumoconioses, malignant neoplasms of the pleura, hypersensitivity pneumonitis, occupational asthma, and other lung conditions. Major additions were sub-sections for pulmonary tuberculosis and chronic obstructive pulmonary disease. Mortality data published in the 1994 and 1996 *World Surveillance Reports* are updated through 1996. The 1994 report contains major additions, including previously unreported data, such as that from the National Health and Nutrition Examination Survey (NHANES). Reports of occupational asthma and silicosis from the Sentinel Event Notification Systems for Occupational Risks (SENSOR) Program are updated through 1995; updated summaries from the Association of Occupational and Environmental Clinics (AOEC) are provided for 1991-1996.

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Special appreciation is expressed for the cooperation of staff at the Occupational Safety and Health Administration (OSHA) and at the Mine Safety and Health Administration (MSHA) for providing exposure data files, to the Association of Occupational and Environmental Clinics (AOEC) for providing data from their occupational disease database, and to state-level SENSOR Program staff, who provided data on silicosis and work-related asthma.

Draft portions of this report were provided for review and comment to individuals associated with public health agencies and other governmental organizations, as well as to others within NIOSH. Their comments have been considered in the final version of this report.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists	MRE	Mining Research Establishment
AOEC	Association of Occupational and Environmental Clinics	MSHA	Mine Safety and Health Administration
BLS	Bureau of Labor Statistics	NCHS	National Center for Health Statistics
BoC	Bureau of the Census	n.e.c.	not elsewhere classified
CDC	Centers for Disease Control and Prevention	NHDES	National Health and Nutrition Examination Survey
CFR	<i>Code of Federal Regulations</i>	NIOSH	National Institute for Occupational Safety and Health
CI	confidence interval	n.o.s.	not otherwise specified
CIC	Census Industry Code	OA	occupational asthma
COC	Census Occupation Code	OSHA	Occupational Safety and Health Administration
COPD	chronic obstructive pulmonary disease	PEFR	peak expiratory flow rate
CWP	coal workers' pneumoconiosis	PEL	permissible exposure limit
CWXSP	Coal Workers' X-ray Surveillance Program	PHS	Public Health Service
CXR	chest x-ray	PMF	progressive massive fibrosis
DFR	Doctor's First Report	PMR	proportionate mortality ratio
DHHS	Department of Health and Human Services	PPD	purified protein derivative
DOL	Department of Labor	REL	NIOSH recommended exposure limit
DRDS	Division of Respiratory Disease Studies	RADS	reactive airways dysfunction syndrome
f/cc	fibers per cubic centimeter	SIC	Standard Industrial Classification
FEV ₁	forced expiratory volume in one second	SSA	Social Security Administration
GM	geometric mean	SENSOR	Sentinel Event Notification Systems for Occupational Risks
HCFA	Health Care Financing Administration	SOP	standard operating procedure
ICD	International Classification of Diseases	SUDAAN®	Survey Data Analysis (software)
ILO	International Labour Office	TLV®	Threshold Limit Value
IMIS	Integrated Management Information System	TWA	time-weighted average
LCL	lower confidence limit	UCL	upper confidence limit
MQC	minimum quantifiable concentration	WOHL	Wisconsin Occupational Health Laboratory
µg/m ³	micrograms per cubic meter	WoRLD	Work-Related Lung Disease
mg/m ³	milligrams per cubic meter	WRA	work-related asthma
MMWR	<i>Morbidity and Mortality Weekly Report</i>	YPLL	years of potential life lost
MNMD	metal/nonmetal mine data		
mppcf	millions of particles per cubic foot		

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Highlights and Limitations

Selected Highlights

The following paragraphs highlight selected findings based on data from the United States presented in this and previous WoRLD Surveillance Reports.

Asbestosis and Related Exposures

- Asbestosis deaths among U.S. residents age 15 and over have increased from fewer than 100 in 1968 to more than 1,250 annually in 1999, the most recent year for which data are available, with no apparent leveling off of this trend. (Figure 1-1)
- Over the 10-year period from 1990 to 1999, there were more than 10,000 asbestosis deaths and annual asbestosis death counts increased by one-third. (Table 1-1)
- During the 10-year period from 1990 to 1999, asbestosis deaths represented about one-third of all pneumoconiosis deaths. (Table 6-6)
- For 1998 and for 1999, asbestosis deaths outnumbered coal workers' pneumoconiosis (CWP) deaths, displacing CWP as the most frequent type of pneumoconiosis death. (Tables 1-1, 2-1, 6-1)
- Asbestosis was designated as the underlying cause of death in one-third of all asbestosis deaths from 1990 to 1999. (Table 1-1)
- Residents of California, Pennsylvania, New Jersey, Texas, Florida, Washington, and Virginia together accounted for nearly half of all asbestosis deaths in the 1990 to 1999 period. (Table 1-4)
- For the period from 1985 to 1999, four counties (one in Virginia, one in Texas, one in Mississippi, and one in New Jersey) had age-adjusted asbestosis mortality rates that exceeded the national rate by more than 20-fold. (Table 1-10)
- Based on a large subset of the national data for which decedents' usual occupation and industry information was available, the *construction* industry

accounted for one-fourth of decedents with asbestosis from 1990 through 1999. Apart from *construction*, asbestosis deaths were reported in a wide range of industries, with no particular industry predominating. Similarly, no one occupation emerged as being particularly common, though the most frequently listed occupational group was *plumbers, pipefitters, and steamfitters*. (Tables 1-6, 1-7)

- From 1990 to 1999, decedents whose death certificate indicated that they worked in the *miscellaneous nonmetallic mineral and stone products* industry or the *ship and boat building and repairing* industry had proportionate asbestosis mortality more than 15 times higher than that of all industries combined. (Table 1-8)
- From 1990 to 1999, decedents whose death certificate indicated that they were *insulation workers* or *boilermakers* had proportionate asbestosis mortality 20 times higher than that in all occupations combined. (Table 1-9)
- Hospital discharges associated with asbestosis have been rising rapidly between 1995 and 2000. (Table 1-11)
- Data from the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) indicate a trend towards lower exposure levels from 1979 to 1999, concomitant with mandated reductions in the OSHA permissible exposure limit (PEL). (Figure 1-5, Table 1-12)
- For the period 1990 to 1999, less than 5% of the MSHA and OSHA asbestos exposures exceeded the recommended exposure limit (REL). The *miscellaneous nonmetallic mineral and stone products* industry, which had the highest proportionate mortality ratio (PMR) for asbestosis, also had the highest geometric mean exposure and the highest percent of exposures

Selected Highlights

exceeding the PEL and REL (26% and 41%, respectively). (Table 1-13)

Coal Workers' Pneumoconiosis (CWP) and Related Exposures

- CWP deaths among U.S. residents age 15 and over continue a long-term decline, from well over 2,500 deaths annually in the early 1980s to just over 1,000 in the late 1990s. (Figure 2-1)
- Similarly, among active underground coal miners examined in a federally-administered CWP screening program, the prevalence of radiographically evident CWP continues to decline – from over 10% in the early 1970s to less than 2% in the late 1990s. (Table 2-12, Figure 2-5)
- CWP deaths accounted for nearly half of pneumoconiosis deaths during the 10-year period from 1990 to 1999, clearly outnumbering deaths associated with other types of pneumoconiosis. (Table 6-6)
- CWP was designated as the underlying cause of death in over one-third of all CWP deaths from 1990 to 1999. (Table 2-1)
- For the decade from 1990 to 1999, more than three-fourths of all CWP decedents were residents of Pennsylvania, West Virginia, Virginia, and Kentucky. Pennsylvania alone accounted for about half of all CWP deaths in this period. (Table 2-4)
- For the period from 1985 to 1999, four counties (one in Virginia, one in Pennsylvania, and two in West Virginia) had age-adjusted CWP mortality rates that exceeded the national rate by more than 100-fold. (Table 2-10)
- A large majority of CWP deaths are associated with employment in the *coal mining* industry, for which proportionate CWP mortality was more than 50 times higher than that of all occupations combined. (Tables 2-6, 2-8)
- Federal "Black Lung" Program payments totaled more than \$1.5 billion for nearly 190,000 beneficiaries in 1999. These figures reflect a continuing slow decline from over \$1.8 billion paid out for over 500,000 beneficiaries in 1980. The number of beneficiaries is now about one-third of what it was in 1980. (Table 2-13)
- Data from MSHA indicate that from the early 1980s to 1999 the underground *coal mining* industry experienced little change in level of exposure to respirable coal mine dust. Surface mine exposure levels have also remained fairly steady although there is some evidence of a decline in exposure levels since the early 1990s. (Figure 2-7, Table 2-14)
- During the period 1995 to 1999, one-fourth of coal mine dust exposures recorded by MSHA exceeded the REL. (Tables 2-15, 2-16)

Silicosis and Related Exposures

- Silicosis deaths among U.S. residents age 15 and over represented nearly 8% of all pneumoconiosis deaths in the U.S. during the 10-year period from 1990 to 1999. (Table 6-6)
- Over the past several decades, silicosis mortality has declined, from well over 1,000 deaths annually in the late 1960s to fewer than 200 per year in the late 1990s. (Figure 3-1)
- Silicosis was designated as the underlying cause of death in half of all silicosis deaths from 1990 to 1999. (Table 3-1)
- Compared to asbestosis, CWP, and byssinosis, silicosis mortality appears to be somewhat less concentrated by geographic region or by industry. However, Pennsylvania, alone, accounts for nearly 18% of silicosis deaths for the 1990-1999 period, ranking first among all states in number of silicosis deaths and fourth in age-adjusted silicosis mortality rate behind West Virginia, Vermont, and Colorado. (Tables 3-4, 3-5)

Selected Highlights

- For the period from 1985 to 1999, six counties (two in North Carolina and one each in Montana, Idaho, Colorado, and Georgia) had age-adjusted silicosis mortality rates that exceeded the national rate by more than 25-fold. (Table 3-10)
- Based on a large subset of the national data for which decedents' usual occupation and industry information was available, the *construction* and *mining* industries accounted for at least one-third of decedents with silicosis from 1990 through 1999. (Table 3-6)
- Throughout the 1990-1999 period, silicosis mortality rates were higher among black males than among white males. (Table 3-2)
- Based on data from the SENSOR silicosis programs in Michigan, New Jersey, and Ohio, more than 8% of confirmed silicosis cases for which duration of exposure was ascertained had less than 10 years of occupational exposure to silica dust. (Table 3-13)
- Data from MSHA indicate that from 1979 to 1999 respirable quartz exposure levels have remained relatively constant in the *coal mining* industry. Levels in the *metal mining* and *nonmetallic mining and quarrying* industries appear to have declined from 1979 to 1987, increased substantially in 1988 when MSHA implemented a different quartz analytical standard, declined from 1989 to 1995 and increased thereafter. Data from OSHA indicate that from 1979 to 1999 respirable quartz exposure levels have declined in the non-mining industries during the period 1989 to 1992 when the OSHA PEL was changed from a formula for respirable dust containing quartz to a respirable quartz concentration of 0.1 mg/m³. (Figures 3-6a, 3-6b, Tables 3-16a, 3-16b, 3-20)
- For the overall period 1993 to 1999, the percentages of exposures greater than the PEL were about 29% in *coal mining*, about 6% in *metal mining* and *nonmetallic mining and quarrying* industries, and 31% in other industries. (Tables 3-18 to 3-20)
- For the overall period 1990 to 1999, *miscellaneous nonmetallic mineral and stone products, iron and steel foundries*, and *structural clay products* were the industries with elevated PMRs for silicosis in which at least 29% of their exposures exceeded the PEL and about half exceeded the REL. The *coal mining* industry had an elevated PMR for silicosis and about 30% of its exposures exceeded the MSHA PEL. (Tables 3-8, 3-17)
- For the period 1993 to 1999, Indiana, Virginia, Tennessee, West Virginia, Oklahoma, Kentucky, Arizona, and Alabama had geometric mean respirable quartz exposure levels in the coal mining industry which exceeded 0.05 mg/m³ MRE and at least 10 samples analyzed by MSHA. (Table 3-18, Figure 3-7)
- For the period 1993 to 1999, 16 states had geometric mean respirable quartz exposure levels in non-mining industries which exceeded the REL of 0.05 mg/m³ and at least 10 samples analyzed by OSHA. (Table 3-20, Figure 3-9)

Byssinosis and Related Exposures

- In comparison with other pneumoconioses, byssinosis deaths among U.S. residents age 15 and over (as enumerated from death certificate data) remain very few – fewer than 20 annually since 1990, and fewer than 10 annually in 1998 and 1999. (Table 4-1)
- Nearly one-third of byssinosis decedents in the 1990 to 1999 period were female. (Table 4-1)
- Byssinosis was designated as the underlying cause of death in about half of all byssinosis deaths from 1990 to 1999. (Table 4-1)
- Over one-half of byssinosis decedents in the period from 1990 to 1999 were residents of North Carolina, South Carolina, and Georgia. (Table 4-4)

Selected Highlights

- For the period from 1985 to 1999, three counties (all in North Carolina) had age-adjusted byssinosis mortality rates that exceeded the national rate by more than 50-fold. (Table 4-10)
- Only one industry – *yarn, thread, and fabric mills* – was associated with a significantly high byssinosis mortality for the 1990 to 1999 period. (Table 4-8)
- Although cotton dust exposure data are sparse, nearly one-third of the exposures measured by OSHA exceeded the REL for the period 1990 to 1999. (Table 4-12)

Unspecified/Other Pneumoconioses

- The pattern of deaths from unspecified/other pneumoconioses, which account for 10% of all pneumoconiosis deaths during the 1990-1999 period, tends to resemble coal workers' pneumoconiosis (and, less so, silicosis) mortality with respect to geographic distribution, a similar peak in 1972, and similar occupations and industries associated with high PMRs. This indicates that most unspecified pneumoconiosis deaths are likely to be CWP deaths. (Tables 5-1, 5-4, 5-8, 5-9, 6-6)
- For each year from 1979 to 1999, at least five percent of OSHA iron oxide fume exposures exceeded the REL. (Table 5-11)

All Pneumoconioses and Related Exposures

- During the 10-year period from 1990 to 1999, there were more than 31,000 pneumoconiosis deaths nationwide, accounting for more than 300,000 years of potential life lost. (Tables 6-1, 6-3)
- Overall pneumoconiosis mortality in the U.S. has been gradually declining over the past two-and-one-half decades, from a peak of more than 5,000 deaths in 1972 to 2,745 pneumoconiosis deaths in 1999. (Figure 6-1, Table 6-1)

- Pneumoconiosis was designated as the underlying cause of death in over one-third of all pneumoconiosis deaths from 1990 to 1999. (Table 6-1)
- The pattern of all pneumoconiosis mortality is largely influenced by coal workers' pneumoconiosis (CWP), given that certified CWP deaths represent nearly half of all pneumoconiosis deaths from 1990 to 1999. However, asbestosis deaths have been increasing and exceeded CWP deaths in 1998 and 1999. (Tables 1-1, 2-1, 6-6)
- Based on a major survey of private industry employers, annual estimates for the number of new cases of pneumoconiosis over the late 1990s have ranged from 1,700 to 3,500 among employees. There is no clear trend in these estimates since 1980. The highest estimated rates have been consistently associated with mining, particularly with *coal mining*. (Tables 6-12 to 6-14)
- For the overall period 1990 to 1999, the *coal mining* industry had the highest PMR (33) for pneumoconiosis and over one-fourth of its exposures exceeded the REL. (Table 6-16)

Malignant Mesothelioma

- There were nearly 2,500 malignant mesothelioma deaths among U.S. residents age 15 and over in 1999. (Table 7-1)
- Mesothelioma was designated as the underlying cause of death in nearly 95% of all malignant mesothelioma deaths in 1999. (Table 7-1)
- Nearly 20% of mesothelioma decedents were female. (Table 7-1)
- For 1999, more than one-third of mesothelioma decedents were residents of just five states (California, Florida, Pennsylvania, New York and Ohio). (Table 7-4)

Selected Highlights

- For 1999, seven counties (two in Virginia, and one each in Ohio, Maine, New Jersey, Mississippi, and Michigan) had age-adjusted malignant mesothelioma mortality rates that exceeded the national rate by more than 5-fold. (Table 7-9)
- Based on a large subset of the national data for which decedents' usual occupation and industry information was available, the *construction* industry accounted for nearly 15% of decedents with malignant mesothelioma in 1999. (Table 7-5)
- In addition to the *construction* industry, other industries associated with significantly increased mesothelioma mortality in 1999 include: *ship and boat building and repairing; industrial and miscellaneous chemicals; petroleum refining; and electric light and power.* (Table 7-7)
- Occupations associated with significantly elevated mesothelioma mortality in 1999 include: *plumbers, pipefitters, and steamfitters; mechanical engineers; electricians; and elementary school teachers.* (Table 7-8)

Hypersensitivity Pneumonitis (HP)

- The annual number of hypersensitivity pneumonitis (HP) deaths has been generally increasing, from less than 20 per year in 1979 to 57 in 1999. (Figure 8-1, Table 8-1)
- HP was designated as the underlying cause of death in two-thirds of all HP deaths from 1990 to 1999. (Table 8-1)
- The highest HP mortality rates for the 1990-1999 period are in the upper Midwest, northern Plains, Mountain, and New England states. (Table 8-5)
- For the 1985-1999 period, two counties in Wisconsin had age-adjusted HP mortality rates that exceeded the national rate by more than 5-fold. (Table 8-10)

- For the 1990-1999 period, *Agricultural production* industries (both *livestock* and *crops*) and *farmers, except horticulture* were associated with significantly elevated PMRs for HP. (Tables 8-8, 8-9)

Asthma

- For the 1990-1999 period, *agriculture production, livestock and farm machinery and equipment* were associated with the highest proportionate mortality ratios for asthma. Among the other top five industries with significantly elevated PMRs for asthma were: *child day care services; drug stores; and health services, not elsewhere classified.* Among the top ten industries associated with significantly elevated PMRs for asthma are two others related to the health care industry: *hospitals and offices and clinics of physicians.* (Table 9-1)
- For the 1990-1999 period, half of the 23 occupational groups associated with significantly elevated PMRs for asthma were related to health care and education. (Table 9-2)
- Public health surveillance programs in four states (California, Massachusetts, Michigan, and New Jersey) have identified over 2,500 cases of work-related asthma over a recent seven-year period (1993-1999). About 80% represented asthma caused by occupational exposure, while 20% represented preexisting asthma aggravated by occupational exposure. (Table 9-3)
- Of all the work-related asthma cases from California, Massachusetts, Michigan, and New Jersey associated with various categories of reported putative agents for 1993-1999, 20% were associated with miscellaneous chemicals, 12% with cleaning materials, 11% with mineral and inorganic dust, 10% with indoor air pollutants, and 4% with welding exposures, among others. (Figure 9-1)

Selected Highlights

- Based on a recent national survey of the U.S. population in which respondents' current industry was ascertained, *elementary and secondary schools and colleges* was the current industry sector associated with an estimated asthma prevalence among nonsmokers that significantly exceeded the estimated 8% prevalence of asthma among all U.S. adult nonsmokers. (Table 9-8)
- Based on the survey noted above, *teachers, librarians and counselors* was the current occupation associated with estimated asthma prevalence among nonsmokers that significantly exceeded the estimated 8% prevalence of asthma among all U.S. adult nonsmokers. (Table 9-11)

Chronic Obstructive Pulmonary Disease (COPD)

- *Coal mining* led the list of industries with significantly elevated PMRs for COPD in 1999. Two other mining sectors were in the top five industries for COPD mortality, as were *trucking service* and *automotive repair and related services*. (Table 10-1)
- The top five occupations for COPD mortality in 1999 included: *washing, cleaning, and pickling machine operators; helpers, mechanics and repairers; textile cutting machine operators; mining machine operators; and construction trades, not elsewhere classified*. (Table 10-2)

Respiratory Conditions due to Toxic Agents

- Based on a major survey of private employers, the average annual estimated number of new cases of respiratory conditions due to toxic agents has decreased to approximately 15,000 for 1999 and 2000, down from annual estimates of about 25,000 in the early and mid-1990s. (Table 11-1)
- The major industry groups associated with the highest annual estimated rates of work-related respiratory conditions due to toxic agents in 2000 are *manufacturing* (3.0 per 10,000 full-time

workers), *services* (1.9 per 10,000 full-time workers), and *transportation and public utilities* (1.5 per 10,000 full-time workers). The *transportation equipment* industry, with annual estimated rates of about 10 per 10,000, has consistently ranked in the top three industry sectors during the 1996 to 2000 period. (Tables 11-2, 11-3)

Respiratory Tuberculosis

- Among the industry sectors associated with significantly elevated tuberculosis mortality in the 1990-1999 period were: health-care industries (*offices and clinics of health practitioners; hospitals; and miscellaneous personal services*); *agricultural production, crops*; and industries with significantly elevated silicosis mortality (*nonmetallic mining and quarrying, except fuel; metal mining; other primary metal industries; coal mining; and construction*). (Tables 12-1, 3-8)
- Among occupations associated with significantly elevated tuberculosis mortality in the 1990-1999 period were agricultural occupations (*farm workers and farmers, except horticulture*), *sailors and deckhands, garbage collectors*, and occupations associated with significantly elevated silicosis mortality (*crushing and grinding machine operators; mining machine operators; construction laborers; and laborers, except construction*). (Tables 12-2, 3-9)

Lung Cancer

- This edition of the *Work-Related Lung Disease Surveillance Report* is the first of the series to include a section on lung cancer – specifically PMRs by industry and occupation. A variety of industries and occupations associated with significantly elevated lung cancer mortality are listed in this section. (Tables 13-1, 13-2)

Other Interstitial Pulmonary Diseases

- This edition of the *Work-Related Lung Disease Surveillance Report* is the first of the series to include a section on other interstitial pulmonary

Selected Highlights

diseases – specifically PMRs by industry and occupation. A variety of industries and occupations associated with significantly elevated other interstitial pulmonary diseases mortality are listed in this section. (Tables 14-1, 14-2)

Various Work-Related Respiratory Conditions

- Data from the Bureau of Labor Statistics Annual Survey and the Association of Occupational and Environmental Clinics Database, both of which include information on a wide range of work-related respiratory diseases, serve to remind readers that there is much more to work-related lung disease and other occupational respiratory diseases than they might otherwise realize. Data are presented on work-related upper airway disorders (e.g., allergic rhinitis, nasal septum perforation), malignant diseases (e.g., nasal and laryngeal, as well as pulmonary and pleural), infectious diseases (e.g., influenza, pneumonia, and Legionnaires' disease),

and other respiratory diseases (e.g., pneumonitis, interstitial fibrosis, etc.). (Tables 15-1 to 15-5)

Smoking Prevalence by Occupation and Industry

- This edition of the *Work-Related Lung Disease Surveillance Report* is the first of the series to include a section on smoking prevalence by industry and occupation. Smoking by itself is an important cause of lung disease and smoking can also compound the adverse effects of occupational exposures. Based on recent data from the National Health Interview Survey, estimated smoking prevalences range widely from 12% among *elementary and secondary schools and colleges* workers to over 40% among *repair services* workers. Similar wide-ranging smoking prevalences are seen among occupational groups. (Tables 16-1 to 16-6)

Selected Limitations

In addition to the following cautions, readers should see Appendix A for other limitations relating to specific sources of data presented in this report.

General

- In this report, every reasonable attempt has been made with the available resources to present comprehensive data on health outcomes and exposures of relevance to work-related lung diseases. The data are drawn from the major existing databases. However, other data may exist which would improve the completeness and reliability of the findings presented in this report. Readers who are aware of other data that should be considered for inclusion in future editions are encouraged to make their suggestions known (see Preface for contact information).
- Statistics in many tables and figures in this report are based on small numbers. Readers are cautioned that these can be unstable. Hence, inferences should be drawn with care, and should take the numerical basis into account.
- A decedent's or survey respondent's usual or current industry and occupation are not always indicative of the industry and occupation associated with the exposure responsible for that individual's work-related disease. Readers are therefore cautioned not to make definitive causative inferences about industries and occupations based solely on the various mortality and morbidity tables presented in this report.

Disease Data

- Work-related respiratory diseases are typically, though not always, chronic and may also have long latencies. As reflected in median ages at death presented in this report for the pneumoconioses, many affected individuals live to or even beyond average life expectancy. The fact that many affected individuals do not die as a direct result of their work-related respiratory disease led to a decision to consider all causes of death, underlying and

contributing, in the development of the summary tables and figures of mortality data presented in this report. In the absence of national incidence and prevalence morbidity data specific to occupational diseases, the intent is to provide a better assessment of disease occurrence and distribution than would be possible if consideration were restricted to underlying causes of death.

- Certifying physicians typically do not list all of a decedent's diseases on the death certificate. Therefore, even though contributing causes of death are considered, the mortality data presented in this report probably underestimate the total occurrence of pneumoconioses and other diseases.
- As with any analysis based on death certificate data, there is undoubtedly some misclassification of cause of death. A treating physician may not correctly diagnose a particular disease during a patient's life or, as mentioned above, a certifying physician may fail to list a correctly diagnosed disease on the death certificate, particularly if another disease was directly responsible for the decedent's death. In addition, the diagnoses listed on the death certificate are sometimes miscoded.
- Data that depend, either directly or indirectly, on physician reporting or recording of occupational disease diagnoses can be influenced significantly by the physician's ability or willingness to suspect and evaluate a relationship between work and health. These, in turn, are influenced by evolving medical/ scientific information, and by the legal, political, and social environment. Some factors may lead to increased diagnosis and recording/reporting (e.g., the Coal Mine Health and Safety Act of 1969 increasing recognition and recording of coal workers' pneumoconiosis), while other factors may reduce occupational disease recognition or reporting by physicians (e.g., long latency between a work exposure and disease development, or concern about involvement in litigation).

Selected Limitations

- Byssinosis and asthma lack the characteristic fibrosis and associated radiographic appearance commonly observed in mineral dust pneumoconioses. In addition, advanced stages of asthma and byssinosis may be difficult to distinguish from other chronic obstructive pulmonary diseases, including those due solely to cigarette smoking. For both these reasons, under-diagnosis may be more likely for byssinosis and work-related asthma than for the radiographically apparent pneumoconioses.
- Categorization of lung diseases for which mortality data are presented in this report is limited by the ICD coding system used for the NCHS multiple cause of death data. Also, ICD-8, ICD-9, and ICD-10 disease rubrics differ somewhat for all types of pneumoconioses (see Appendix C). However, the effect of ICD changes is not substantial for most of the diseases under consideration (e.g., there is no indication of any changes in the yearly trend in national silicosis mortality related to changes in the rubrics for the ICD code related to silicosis).
- Prior to ICD-10, there was no discrete ICD code for malignant mesothelioma, a disease strongly associated with exposure to asbestos. ICD-10 coding of national death data in the United States began with 1999 deaths; thus, only one year of malignant mesothelioma data is presented in this report. Past reports in this *Work-Related Lung Disease Surveillance Report* series have presented data on mortality associated with "malignant neoplasm of the pleura," but that former ICD category lacked specificity and sensitivity for malignant mesothelioma.
- A general assumption of work-relatedness for pneumoconiosis deaths is reasonable for surveillance purposes. However, a very small proportion of pneumoconiosis decedents may have developed their disease as a result of non-occupational (e.g., avocational) exposure to pneumoconiotic agents.
- Although respiratory diseases other than the pneumoconioses can be caused by occupational exposure to respiratory hazards, it is generally unreasonable to assume an automatic occupational etiology because of the strong influence of non-occupational factors. As a result, readers will note that the types of mortality tables presented in this report differ depending on the specific disease. More comprehensive tables are presented for those diseases that are highly specific for occupational etiology, while a more limited approach is used for diseases that are less likely to be caused solely by occupational exposure.
- Individuals affected by chronic diseases with long latency have much more time to change residences prior to death than individuals affected by acute diseases with short latency. Thus, state of residence at death does not necessarily represent the location of a decedent's occupational exposure, even for a death that results directly from occupational respiratory disease.
- Readers are reminded that only about half the states provide data on usual industry and occupation of decedents which meet the National Center for Health Statistics' quality criteria for the national death data files used to develop many of the tables presented in this report (see Appendix E).
- Apparent differences in mortality rates may reflect, in part or in whole, geographical as well as temporal changes in employment patterns affecting the number of workers at risk to various respiratory hazards. Denominators used to calculate mortality rates presented in this report are based on general population estimates for the location (e.g., national, state, or county) and for the years in which the deaths occurred. The resulting rates have clear public health significance. However, as suggested by some very high proportionate mortality ratios presented in this report for specific industrial and occupational groups, national and state-specific rates typically represent a dilution of very high mortality among

Selected Limitations

exposed groups of workers by very low mortality within the general population that is not significantly exposed.

- To comply with current CDC policy, population-based mortality rates for this edition of the *Work-Related Lung Disease Surveillance Report* have been adjusted to the U.S. Year 2000 Standard Population. This is a change from prior editions in which rates were adjusted to the 1940 standard population. Readers are cautioned that rates are not directly comparable with those shown in earlier editions.
- Proportionate mortality ratios (PMRs) reported in this edition of the *Work-Related Lung Disease Surveillance Report* are not directly comparable to those reported in earlier editions because PMRs in the current edition have been adjusted for age (in five-year categories), sex, and race, whereas PMRs in earlier editions were adjusted only for age (in 20-year categories). Readers are also reminded that, because of the lack of smoking information in the national death files, PMRs presented in this report have not been adjusted for smoking.
- Over the period covered by data presented in this report, median ages at death have generally increased for all pneumoconioses. The reader is cautioned to realize that this increase is the result of many factors, only one of which may be a general reduction of disease severity (e.g., due to enhanced diagnostic sensitivity and fewer severe cases). Another possible factor is a reduced number of younger workers at risk due to changing employment patterns. Reduced mortality from other causes of death is undoubtedly another important factor.
- Data from the Coal Workers X-Ray Surveillance Program (CWXSP) have a number of limitations. The program is restricted to currently employed miners and participation rates are generally low. Disease prevalence estimates may be biased due to

selective participation, and missing or inaccurate work history information may affect tenure calculations. Also, radiographic detection of pneumoconiosis is imperfect. Pathologic disease in some individuals may not be detected radiographically and, although rare among working populations, various non-occupational conditions may result in radiographic abnormalities consistent with pneumoconiosis.

- The main usefulness of the Bureau of Labor Statistics (BLS) Annual Survey of Injuries and Illnesses is to assess occupational injuries, because work-attribution of traumatic injuries is typically quite clear to the employers. In contrast, work-related diseases are generally under-recognized and under-reported by employers.

Exposure Data

- The reported OSHA and MSHA exposure data should be considered provisional and subject to revision. The samples were collected for regulatory compliance purposes, rather than for the surveillance of worker exposures, and therefore may not represent exposures typically experienced by workers. Nonetheless, these data provide the best available national exposure information for industries in the U.S.
- MSHA and OSHA data for similar agents are presented in this report in a parallel format. The reader is cautioned that MSHA and OSHA are separate agencies with separate regulatory jurisdictions over different industries. The number of compliance samples collected by an agency depends upon many factors, including the size and nature of an industry, congressional actions, and regulatory policies.
- To identify pneumoconiotic agents included in the MSHA and OSHA data systems, the following documents were reviewed: *Documentation of TLVs® and BEIs®, 6th edition* (ACGIH7); *Occupational Respiratory Diseases* (NIOSH Pub.

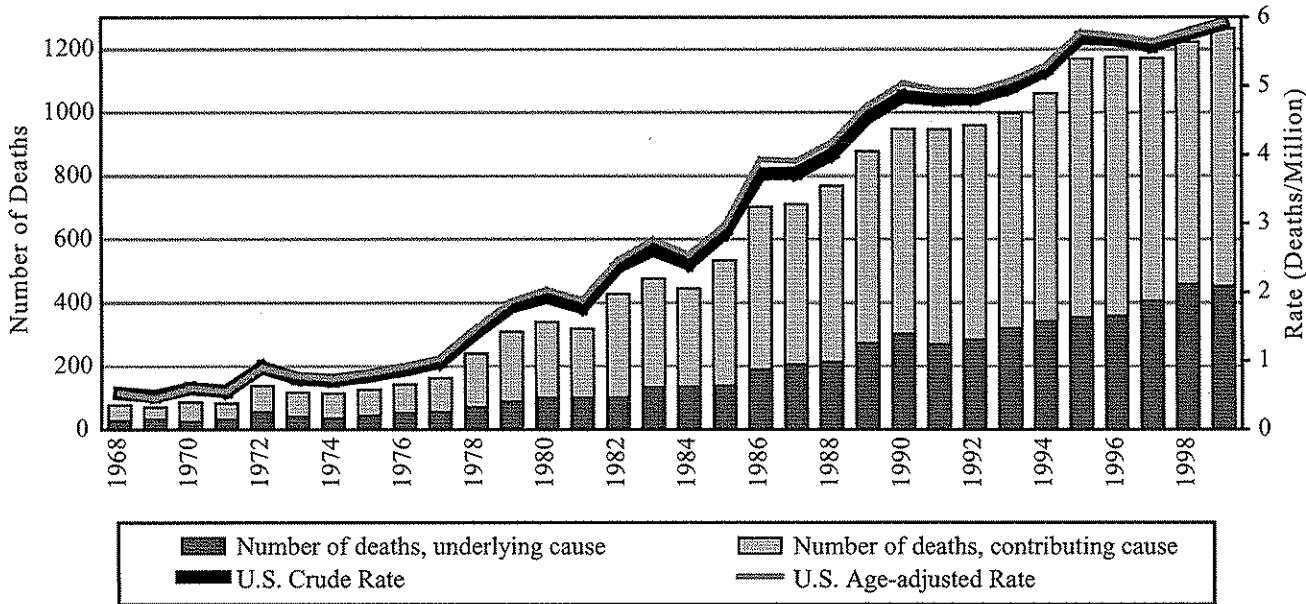
Selected Limitations

No. 86-102); the *Pocket Guide to Chemical Hazards* (NIOSH Pub No. 97-140); and various NIOSH Criteria Documents. The resulting list of pneumoconiotic agents (see Table F-1 of Appendix F) represents those agents associated with the most prevalent types of pneumoconiosis, but is not intended to be a complete listing of all agents that may cause pneumoconiosis.

- Many of the reported geometric mean exposures include samples that could not be quantified with the sampling and analytical methods used. Rather than assume the values of these samples were zero, estimates of the sample results were used to calculate the geometric mean. The methods for estimating the sample result are described in the exposure section, and readers should keep in mind this uncertainty underlying the geometric mean concentrations presented in this report.
- Although OSHA adopted permissible exposure limits (PELs) of 0.1 mg/m³ for quartz and 0.05 mg/m³ for cristobalite that were enforced from March 1, 1989 through March 22, 1993, neither OSHA nor MSHA currently has a PEL specific to any form of crystalline silica. Instead, the relevant PELs are for respirable dust containing crystalline silica. These PELs take the form of formulas in which the PEL for respirable dust is reduced as the crystalline silica content of the dust increases. The PEL formulas vary with the agency and the industry, but, with all of them, the effective allowable exposure to quartz is less than or equal to 0.1 mg/m³ and the effective allowable exposure to cristobalite is less than or equal to 0.05 mg/m³, regardless of silica content. Thus, the percentage of OSHA samples exceeding the PEL is greater in the years when the formula PEL is applied (in this report, all years except 1989 through 1993) than it would be if a 0.1 mg/m³ quartz or 0.05 mg/m³ cristobalite PEL had been applied for these years. Readers should keep the preceding explanation in mind when considering data presented in this report showing apparent temporal discontinuities in the annual percentage of OSHA silica samples exceeding the PEL.
- The percentage of respirable coal mine dust samples exceeding the PEL was calculated using the MSHA PEL of 2 mg/m³ MRE for respirable coal mine dust containing no more than 5% quartz. Because the quartz content could not be reliably identified for most of the respirable coal mine dust samples, no attempt was made to use the MSHA formula for reducing the PEL when the quartz content exceeded 5%. Thus, as presented in this report, the percentage of respirable coal mine dust samples exceeding the PEL is a lower limit, and the actual percentage exceeding the PEL is very likely higher than reported.
- In addition to samples in which quartz was identified, the respirable quartz data reported in Section 3 include MSHA samples identified as:
 - nuisance dust, respirable fraction, less than 1% quartz;
 - unlisted particulate, respirable fraction, less than 1% quartz; and
 - respirable dust (not analyzed or below detection limit) from metal/nonmetal mines because, although the samples did not indicate quartz exposure, they were collected, in part, to assess exposure to quartz. This provides a more accurate estimate of the geometric mean exposures and the percentage of exposures that exceed a PEL or recommended exposure limit (REL).
- Available exposure data for agents associated with each type of pneumoconiosis are presented in this report following the presentation of mortality data for that same condition. The reader is reminded that the time period over which the exposure data were collected does not necessarily correspond to the time period during which most of the decedents represented in the mortality data acquired their disease. For most pneumoconiosis deaths, there is a latency period of at least several years between first occupational exposure and onset of disease. Subsequent death typically occurs many years after disease onset.

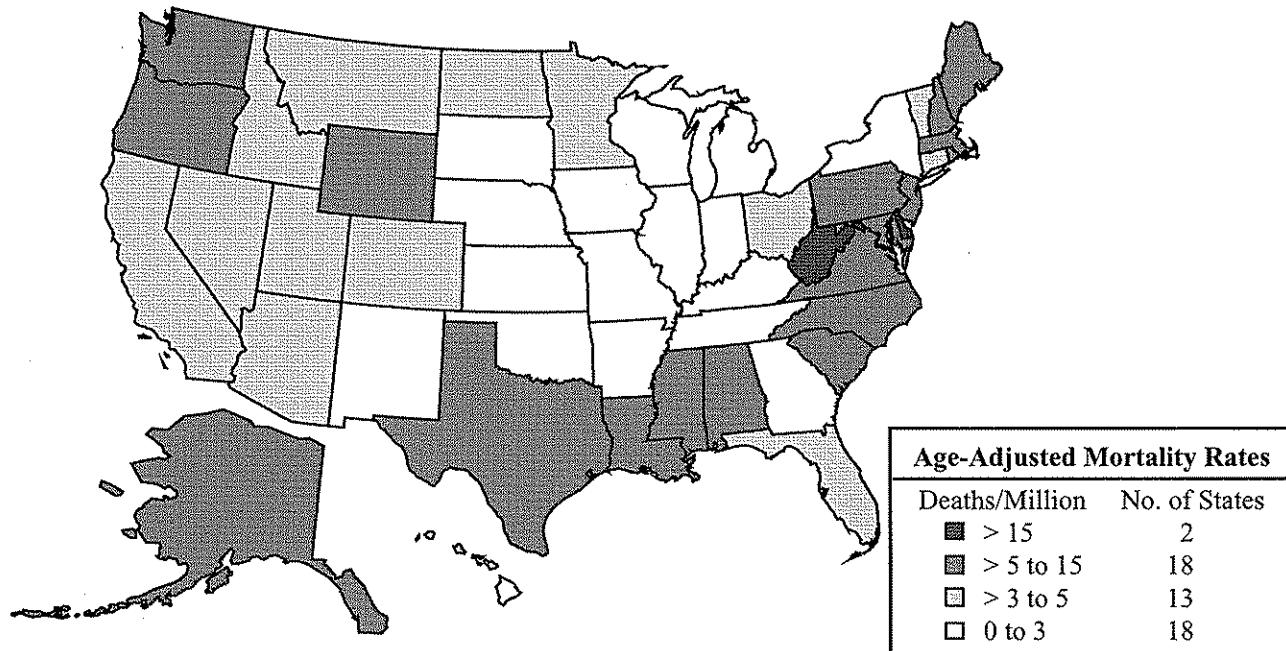
Section 1

Asbestosis and Related Exposures

*Asbestosis: Mortality***Figure 1-1. Asbestosis: Number of deaths, crude and age-adjusted mortality rates, U.S. residents age 15 and over, 1968-1999**

NOTE: See appendices for source description, methods, and ICD codes.

SOURCE: National Center for Health Statistics multiple cause of death data. Population estimates from U.S. Bureau of the Census.

Figure 1-2. Asbestosis: Age-adjusted mortality rates by state, U.S. residents age 15 and over, 1990-1999

NOTE: See appendices for source description, methods, and ICD codes.

SOURCE: National Center for Health Statistics multiple cause of death data. Population estimates from U.S. Bureau of the Census.

Asbestosis: Mortality

Table 1-1. Asbestosis: Number of deaths by sex, race, and age, and median age at death, U.S. residents age 15 and over, 1990-1999

Year	No. of Deaths	Under-lying Cause (%)	Sex		Race			Age Group (yrs)					Median Age (yrs)			
			Male	Female	White	Black	Other	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	
1990	948	31.9	901	47	864	78	6	—	—	4	18	142	359	336	89	74.0
1991	946	28.4	908	38	877	63	6	1	—	1	25	114	370	358	77	74.0
1992	959	29.6	923	36	898	57	4	—	—	3	13	124	371	355	93	74.0
1993	999	32.0	969	30	934	58	7	—	—	1	20	110	365	396	107	75.0
1994	1,060	32.2	1,026	34	993	62	5	—	—	2	21	94	410	422	111	75.0
1995	1,169	30.4	1,138	31	1,095	69	5	—	—	3	24	118	411	477	136	75.0
1996	1,176	30.4	1,123	53	1,088	84	4	—	—	3	16	104	428	480	145	75.0
1997	1,171	34.6	1,128	43	1,106	60	5	—	—	—	15	95	363	516	182	77.0
1998	1,221	37.5	1,177	44	1,153	62	6	—	1	1	11	97	394	524	193	76.0
1999	1,265	35.7	1,225	40	1,190	64	11	—	—	—	15	89	390	563	208	77.0
TOTAL	10,914	32.5	10,518	396	10,198	657	59	1	1	18	178	1,087	3,861	4,427	1,341	75.0

- indicates no deaths listed.

NOTE: See appendices for source description, methods, and ICD codes.

SOURCE: National Center for Health Statistics multiple causes of death data.

*Asbestosis: Mortality***Table 1-2. Asbestosis: Mortality rates (per million population) by race and sex, U.S. residents age 15 and over, 1990-1999**

Year	Overall	White		Black		Other	
		Male	Female	Male	Female	Male	Female
						Crude Mortality Rate	
1990	4.85	10.23	0.51	7.40	0.17	1.44	0.27
1991	4.80	10.42	0.42	5.86	0.16	1.66	—
1992	4.82	10.63	0.37	5.00	0.32	1.06	—
1993	4.97	11.03	0.32	5.19	0.16	1.82	—
1994	5.22	11.62	0.35	5.38	0.23	1.26	—
1995	5.70	12.74	0.35	6.19	—	1.23	—
1996	5.67	12.26	0.57	7.22	0.15	0.93	—
1997	5.58	12.49	0.44	4.93	0.22	1.13	—
1998	5.75	12.94	0.45	5.09	0.15	1.09	0.28
1999	5.90	13.28	0.42	5.26	0.07	2.33	—
1990-1999	5.32	11.76	0.42	5.70	0.16	1.40	0.04
Age-Adjusted Mortality Rate							
1990	5.04	12.34	0.43	12.59	0.18	3.43	0.40
1991	4.94	12.31	0.35	10.25	0.19	3.23	—
1992	4.93	12.54	0.30	8.51	0.38	1.94	—
1993	5.08	13.05	0.27	9.37	0.22	3.53	—
1994	5.30	13.57	0.29	8.96	0.31	2.58	—
1995	5.79	14.78	0.28	11.74	—	2.66	—
1996	5.73	14.21	0.46	12.30	0.18	1.89	—
1997	5.66	14.69	0.35	8.59	0.29	2.35	—
1998	5.78	14.89	0.36	9.08	0.19	1.87	0.36
1999	5.93	15.17	0.34	9.97	0.09	3.83	—
1990-1999	5.41	13.76	0.34	10.10	0.20	2.78	0.08

— indicates no deaths listed.

NOTE: See appendices for source description, methods, and ICD codes.

SOURCE: National Center for Health Statistics multiple cause of death data. Population estimates from U.S. Bureau of the Census.

*Asbestosis: Mortality***Table 1-3. Asbestosis: Years of potential life lost to age 65 and to life expectancy by race and sex, U.S. residents age 15 and over, 1990-1999**

Year	White		Black		Other		Total
	Male	Female	Male	Female	Male	Female	
Years of Potential Life Lost to Age 65							
1990	930	25	90	25	10	—	1,080
1991	845	30	130	—	10	—	1,015
1992	780	15	50	30	15	—	890
1993	820	20	35	—	—	—	875
1994	710	15	110	—	—	—	835
1995	930	10	55	—	30	—	1,025
1996	715	25	70	—	25	—	835
1997	660	—	40	—	—	—	700
1998	605	45	50	—	10	—	710
1999	585	10	50	—	25	—	670
Total	7,580	195	680	55	125	—	8,635
Years of Potential Life Lost to Life Expectancy							
1990	9,038	558	771	51	70	14	10,502
1991	9,294	466	664	28	87	—	10,539
1992	9,419	392	546	81	66	—	10,504
1993	9,541	357	529	17	87	—	10,531
1994	10,074	353	657	29	59	—	11,172
1995	11,245	351	637	—	87	—	12,320
1996	10,741	571	840	28	67	—	12,247
1997	10,652	408	582	30	54	—	11,726
1998	11,189	457	593	23	75	9	12,346
1999	11,436	407	592	14	170	—	12,619
Total	102,629	4,320	6,411	301	822	23	114,506

— indicates no deaths listed.

NOTE: See appendices for source description, methods, and ICD codes.

SOURCE: National Center for Health Statistics multiple cause of death data.